CLAIMS

What is claimed is:

1. A method for determining abnormal consumption of a utility by a system:

repeatedly measuring the level of use of the utility thereby producing a plurality of utility measurements;

employing a statistical procedure to identify any outliers in the plurality of utility measurements; and

evaluating performance of the system in response to any outliers identified.

2. The method as recited in claim 1 wherein evaluating performance of the system comprises determining a severity of abnormal utility usage represented by an outlier.

3. The method as recited in claim 2 wherein determining a severity of abnormal utility usage comprises calculating how many standard deviations a given outlier is from the average value for utility usage by using the expression:

$$z_j = \frac{x_{e,j} - \bar{x}_{robust}}{s_{robust}}$$

where $x_{e,j}$ is the energy consumption for the j^{th} outlier, $\bar{x}_{robust}$ is a robust estimate of the average energy consumption for days of the same day type as outlier j, and s_{robust} is a robust estimate of the standard deviation of energy consumption for days of the same day type.

4. The method as recited in claim 2 wherein determining a severity of abnormal utility usage comprises calculating a standard deviation of each outlier.

5. The method as recited in claim 2 wherein determining a severity of abnormal utility usage comprises determining an amount that each outlier deviates from a mean of the plurality of utility measurements which are not identified as outliers.

6. The method as recited in claim 1 further comprising separating the plurality of utility measurements into groups wherein each group contains utility measurements acquired during days that under normal conditions have similar utility consumption levels; and

wherein the statistical procedure is applied separately to each group.

7. The method as recited in claim 1 further comprising separating the plurality of utility measurements into groups wherein each group contains utility measurements acquired during predefined time periods that under normal conditions have similar utility consumption levels; and

wherein the statistical procedure is applied separately to each group.

8. The method as recited in claim 1 wherein the outliers are identified using a Generalized Extreme Studentized Deviate (GESD) statistical procedure.

9 The method as recited in claim 8 wherein employing a statistical procedure involve utilizing a Generalized Extreme Studentized Deviate (GESD) statistical procedure comprising:

(a) calculating an arithmetic mean $(\bar{x})$ of the plurality of utility measurements;

(b) finding an extreme utility measurement $x_{e,i}$ which is the utility measurement that has a value which is farther numerically from the arithmetic mean $(\bar{x})$ than the other ones of the plurality of utility measurements;

(c) using the extreme utility measurement $x_{e,i}$ to calculate an extreme studentized deviate R_i;

(d) calculating a 100α percent critical value λ_i for the extreme utility measurement $x_{e,i}$;

(e) declaring the extreme utility measurement $x_{e,i}$ to be an outlier when the extreme studentized deviate R_i is greater than the 100α percent critical value λ_i.

10. The method as recited in claim 9 further comprising:

removing the extreme utility measurement $x_{e,i}$ from the plurality of utility measurements to form a new plurality of utility measurements; and

repeating steps (a) through (e) for the new plurality of utility measurements.

11. The method as recited in claim 9 wherein the extreme studentized deviate R_i is calculated according to the expression:

$$R_i = \frac{\left| x_{e,i} - \bar{x} \right|}{s}$$

where s is a standard deviation of the plurality of utility measurements.

12. The method as recited in claim 9 wherein the 100α percent critical value λ_i then is calculated using the equation:

$$\lambda_i = \frac{(n-i)t_{n-i-1,p}}{\sqrt{(n-i+1)\left(n-i-1+t^2_{n-i-1,p}\right)}}$$

where n is the number of utility measurements, i is a number identifying a particular outlier being evaluated, $t_{n-i-1,p}$ is a student's t-distribution with $(n-i-1)$ degrees of freedom, and p is a value based on the user defined probability α of incorrectly declaring one or more outliers when no outliers exist.

13. The method as recited in claim 12 wherein percentile p is determined from:

$$p = 1 - \left(\frac{\alpha}{2(n - i + 1)} \right) .$$

14. A method for determining abnormal consumption of a utility by a system:

(a) repeatedly measuring the level of use of the utility, thereby producing a plurality of utility measurements;

(b) forming a group of those of the plurality of utility measurements taken during predefined periods of time;

(c) calculating an arithmetic mean $(\bar{x})$ of the group;

(d) finding an extreme utility measurement $x_{e,i}$ which is the utility measurement having a value that is farthest numerically from the arithmetic mean $(\bar{x})$;

(e) using the extreme utility measurement $x_{e,i}$ to calculate an extreme studentized deviate R_1;

(f) calculating a 100α percent critical value λ_i for the extreme utility measurement $x_{e,i}$;

(g) declaring the extreme utility measurement $x_{e,i}$ to be an outlier indicative of abnormal utility use when the extreme studentized deviate is greater than the 100α percent critical value;

(h) removing the extreme utility measurement $x_{e,i}$ from the group of utility measurements; and

(i) repeating steps (c) through (h) a defined number of times.

15. The method as recited in claim 14 wherein the extreme studentized deviate R_i is calculated according to the expression:

$$R_i = \frac{\left| x_{e,i} - \bar{x} \right|}{s}$$

where s is a standard deviation of the plurality of the group of utility measurements.

16. The method as recited in claim 14 wherein the 100α percent critical value λ_i is calculated using the equation:

$$\lambda_i = \frac{(n-i)t_{n-i-1,p}}{\sqrt{(n-i+1)\left(n-i-1+t^2_{n-i-1,p}\right)}}$$

where n is the number of utility measurements, i is a number identifying a particular outlier being evaluated, $t_{n-i-1,p}$ is the student's t-distribution with $(n-i-1)$ degrees of freedom, and p is a value based on the user defined probability α of incorrectly declaring one or more outliers when no outliers exist.

17. The method as recited in claim 16 wherein percentile p is determined from:

$$p = 1 - \frac{\alpha}{2(n-i+1)} .$$

18. The method as recited in claim 14 further comprising defining periods of time during a plurality of days in which under normal conditions similar utility consumption levels occur during each one of those periods of time.

19. The method as recited in claim 14 further comprising performing maintenance on the system in response to examination of one or more of the outliers.